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ABSTRACT

This paper presents a case study of Aaron, a 9-year-old Australian gifted student who has exhibited an outstanding interest and knowledge in science and mathematics, while at the same time displaying unusual behavioral and learning characteristics typified by inconsistent performance of many routine tasks. Aaron attends a moderately sized parochial school and is enrolled in the enrichment program. The report includes perspectives from his parents and his teachers on his abilities, and analyzes his behaviors in the light of theoretical models of giftedness. Characteristics of the gifted are described, including their ability to analyze, synthesize, and evaluate newly acquired information, and their decontextualization skills in constructing solutions to new problems. The ability of gifted students to possess appropriate and necessary cognitive architecture to function exceptionally in one dimension, but not in others, is explained. Aaron's insight, creativity, and abilities in mathematical problem solving are also examined. The key strands of an intervention pull-out model for Aaron are described, which include expanding experiences, establishing a social environment, cognitive apprenticeship (which includes six teaching methods: focus, coaching, scaffolding, articulation, reflection, and exploration), development of affect, cooperative groups, and knowledge creation. (Contains 57 references.) (CR)

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ED 415 620

The difficulties of a young gifted child: Lessons from history

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Abstract

From a very young age Aaron has displayed exceptional ability and interest in board games, reading and mathematics, and a concern for social justice. He was noted for his ability to read house plans and use street directories and maps to guide drivers to their destinations. His drawings are exceptionally detailed and display a strong sense of spatial awareness and geometry. However, although Aaron becomes absorbed in science and mathematical activities he is frustrated with normal classroom tasks which he often leaves unfinished preferring to focus on real world problems and issues. Indeed, in the classroom he is often difficult to manage and is at risk of becoming an underachiever. His behaviours are reminiscent of those displayed by non-conforming gifted children, including Einstein, Newton, Pascal and Russell all of whom had difficult experiences in formal education. The challenge facing teachers and parents is to recognise and cater for children like Aaron to ensure that their unusual talents are realised.

Introduction

Background

This paper describes our experiences with Aaron, currently a nine-year old, who has exhibited an outstanding interest and knowledge in science and mathematics while at the same time displaying unusual behavioural and learning characteristics typified by inconsistent performance on many routine tasks. Aaron came to our attention when he was eight years old as a participant in an enrichment programme that catered for the needs of children with an interest in science and mathematics (Diezmann & Watters, 1995).

The programme served groups of about 15 children aged between 5 and 8 years who attended 90 minute workshops at the University on a weekly basis for a period of 10 weeks. The focus of the workshops was on expanding the children's interests in science and mathematics, developing social skills and helping them become autonomous learners and problem solvers.

All primary schools in the metropolitan area of Brisbane (over 400) were invited to nominate children for the programme. The nomination forms for the enrichment programme provided a broad statement of criteria that were used for selection. These criteria included level of task commitment, creative thought, spatial skills, and mathematical and science aptitude. The attention of teachers was also drawn to potentially underachieving gifted children. Selection of children was based, not just on demonstrated ability, but also on perceived need. Many children who attended were identified as being bored, unco-operative and at risk in a normal classroom, while others needed a challenge or individual stimulation or were referred by counsellors.

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The Case of Aaron

Aaron's Profile

Aaron was nominated by his classroom teacher with the support of the school principal and parents to participate in the enrichment programme. He attends a moderately sized parochial school in a middle socio-economic outer suburb. He has professional parents who both work and are strongly committed to their child's education. The school displays a strong community focus and caring environment with

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highly dedicated and supportive teachers. The parents and the teacher provided a written profile supporting Aaron's nomination for the programme. The parents' description presented Aaron as child with an interest in science and mathematics. *"From an early age he has insisted on watching Quantum, Beyond 2000 and nature documentaries. He appears to absorb the information and often accurately recalls details at a later date. He loves to perform his own scientific experiments at home. He enjoys mathematics and particularly likes learning new concepts."*

The teacher's perceptions of Aaron corroborates the parents' *view" Aaron enjoys Maths and Science, particularly hands-on work, problem-solving."*

The parents particularly noted his spatial ability: *"He has been described as an extremely visual child and his drawings and paintings are exceptional for his age. He also has no difficulty reading house plans or consulting street directories. His orientation is extremely good and he can direct a driver when approaching a familiar location from an unfamiliar direction."*The teacher also commented on his drawing ability: *"he spends a lot of time and effort on very detailed drawings which he enjoys describing and returning to, and which show a maturity beyond his actual age."*

Comments from the parents indicated that Aaron was already a high achiever in activities such as chess, board games and music which are linked to spatial ability: *"He insisted on learning chess aged 4 years and within 6 months was able to beat the computer program "Battle Chess." He enjoys all board games requiring skill and shows aptitude in this area ... He recently sat for his Year 1 Trinity College music exams and has no difficulty mastering the intricacies and concepts of practical and theoretical music."*

Aaron was also a high achiever in some aspects of language. His parents commented on his reading: *"Aaron's reading ability is good and developed early";*while his teacher mentioned the maturity of his vocabulary*: "(he) uses very sophisticated language in story writing."*

The teacher related his competence to the difficulty of the task: *"He enjoys a challenge, and becomes extremely focused when something engages his interest and will pursue a topic in further depth, initiating further discussion on the topic himself ... he exhibits competence at tasks well beyond (his) age."*The teacher also noted the negative effects that some tasks had on his classroom behaviour*: "at times he is disruptive when activities may not be challenging."*

In addition to erratic classroom behaviour the teacher also noted that Aaron was not a consistent high achiever or particularly productive in the classroom: *"he does not appear to excel in normal classroom activities (but handles comfortably with minimum effort; tasks often unfinished) ... but not a great output of finished work."*

The teacher was reflective in considering Aaron's behaviour and performance on routine practice tasks: *"perhaps he cannot see the need for them ... although it may be practice of a basic skill that he has not fully mastered accurately, e.g. No. facts + - to 20."*She added that it was not his mathematical competence that was the cause of his errors but rather his mode of working*: "no problems except (he) rushes and does not take care reading (the) sign so answers inaccurately; may not read directions carefully, therefore writes what he thinks should be (there)."*

Although the teacher appeared to realise the impact of the classroom environment on Aaron she cited the curriculum as a constraining factor and indicated that the enrichment programme had potential benefits not only for Aaron out of class but in providing appropriately for Aaron in the classroom: *"(Aaron) Often displays keen interest in many topics which arise in class in general discussion, but cannot be pursued further because of time (etc. curriculum constraints) ... I think Aaron would benefit from a program such as this which would stimulate him, and extend him in his areas of interest ... It would be useful to know whether his concentration level and on-task behaviour are constant throughout a program like this, as his classroom work is variable feedback would be great."*In accordance with the teacher's request feedback and suggestions for catering for Aaron within the classroom were provided at the conclusion of the programme.

Aaron's acceptance into the programme was based not only on his reported ability but because of the

teacher's concern that the classroom environment was not meeting his particular educational needs, from which it could be inferred that he was potentially "at risk." Interestingly, that while there is concurrence between the teacher and parents with regard to Aaron's interests and abilities, the teacher alone raised the concern about Aaron's classroom performance. Thus the picture presented of Aaron was one of a child with a strong interest in science and mathematics and a large knowledge base on which to draw. He was clearly described as exceptional in comparison with his peers in the classroom in his interests and knowledge. However, a striking feature was his erratic task commitment and performance.

Were these characteristics demonstrated in the enrichment programme? Aaron participated fully in the enrichment programme and evaluative feedback from him and his parents suggested that he enjoyed the experience. Observations of his behaviours indicated that he worked consistently. He often followed up the activities at home and brought them along to show the following week. He was particularly interested in chemistry, the human body, flight, parachutes and motorised vehicles. He also enjoyed and participated in lively discussions. Clearly, the environment provided in the programme motivated him and allowed him to function at an advanced level in tasks of his selection. Furthermore, his attitude and behaviour at school during the programme also changed. He became more co-operative in doing routine work and less aggravated by the classroom environment. He shared many of his experiences with his classmates and demonstrated a number of the activities to them. This behaviour enhanced his standing in the class among his peers.

Twelve months after he completed the programme, as a follow-up, Aaron was observed in his classroom and interviewed with the co-operation of his parents. Discussions were undertaken with his current and previous teachers and with his parents. Aaron was interviewed for some six hours spread over two successive days at the University. During this interview he was engaged in completing a series of psychometric tasks, mathematics problem solving, science problems and open-ended activities of personal interest. The interviews and activities were audio- and video-recorded.

Detailed performance on specific tasks are described later. However, his high spatial skills, breadth of knowledge, enthusiasm, and co-operative nature were evident. Although he was very proficient verbally, his reading aloud was stilted.

Given these profiles and observations can we consider Aaron to be gifted and if so is he an underachiever? Exceptional ability and interest in an individual are a necessary but not sufficient condition for the realisation of giftedness. In tasks where Aaron shows interest he is committed and achieves but in other tasks commitment is not shown. Is there an underlying explanation for this "erratic" behaviour that can be used to build appropriate intervention strategies? To answer these questions we will consider some of the issues concerned with the conceptualisation of giftedness.

Aetiology of Aaron's behaviours

The behaviours of Aaron need to be analysed in the light of theoretical models of giftedness. In current conceptualisations of intelligence researchers have generated notions of multi-talents (Gardner, 1983; Sternberg, 1988), and postulated specific neurological systems and processes (Luria, 1973) or implicated the socio-cultural circumstances as mediators of cognitive development (Vygotsky, 1978). Thus high intelligence giftedness is a multifaceted human behaviour conditional on a number of factors:

> *viewed narrowly is good test-taking skills or, more appropriately, as a combined result of genetics, cultural heritage, environmental opportunity, which leads to a superior ability to process information.* (Bireley p.30)

We begin to understand some characteristics of Aaron if we consider a multi-talent model of giftedness. Gardner (1983) postulated a multidimensional model based on seven relatively autonomous demonstrations of intelligence: linguistic, musical, logico-mathematical, spatial, bodily-kinaesthetic, interpersonal and intrapersonal. This model broadens the conceptualisation of giftedness and suggests the possibility of asynchronous behaviour dependent on the extent to which children excel in any of these dimensions. Thus we see in Aaron indications of high spatial, musical, linguistic, and intrapersonal intelligence.

From a cognitive perspective one recognises in the gifted greater efficiency of information processing, enhanced attention, a repertoire of effective strategies, and intense motivation. Davidson and Sternberg (1984) have argued that insight, the integration of these aspects, is a key attribute that distinguishes the gifted from the non-gifted. If we turn to Sternberg and Luria we begin to understand further the asynchronous nature of Aaron's cognition and see theoretical foundations on which to implement intervention strategies.

The information processing components postulated by Sternberg (1988) are: metacomponents, performance components and knowledge-acquisition components. Although all people possess these components the gifted display these to a greater degree. *Metacomponents*are demonstrated through higher levels of executive planning and decision-making skills. Gifted students' metacognitive proficiency also extends to their knowledge about strategies which optimise remembering, for example *remembering cues*(Borkowski & Kurtz, 1984). Thus, gifted performance reflects superior metacognitive ability manifested in a perceptive understanding of their own cognitive strategies and subject to self-appraisal and management (Cheng, 1993; Paris & Winograd, 1990). Cheng (1993) argues that metacognition is an important characteristic displayed in the gifted, and metacognitive performance and flexibility of cognitive style are distinguishing characteristics of giftedness. Paris, Jacobs and Cross (1987) have constructed a taxonomy in which they identify two classes of metacognition each with three types. The first class is an awareness of cognition, knowing about knowing, and distinguishes three types of knowledge: declarative, procedural and conditional. These knowledge forms are essentially knowledge about facts, strategies and when certain events impact on thinking. A second class of metacognition includes a dynamic control of thinking through evaluation, planning and regulation.

In contrast to the higher order nature of metacomponents, *performance components*are lower order processes which execute metacomponential decisions. For example, inductive reasoning involves the processes of encoding, inference, mapping, application, comparison, justification and response which may be used in tasks such as matrices, analogies, series completion and classifications (Sternberg, 1990).

The gifted also excel in their ability to analyse, synthesise and evaluate newly acquired information, and in their decontextualisation skills in constructing solutions to new problems requiring transfer of previously learned strategies and content. These *knowledge acquisition components*include selective encoding (disembedding relevant information), combination (building relationships between information) and comparison of information (making appropriate links with stored information). The proficiency and integration of these processes to a high order is manifested as insight (Davidson, 1986). Achieving gifted children possess the capacity to generate insight spontaneously to produce solutions to novel problems. Insightful thinking, the ability to redefine and reconceptualise a problem, is the key to creativity and the optimal outcome of problem solving.

Supporting Sternberg's focus is the neuropsychological analysis of information processing explored by Luria (1973). Luria's model posits that information is processed in two possible modes-simultaneous and successive, regulated by control functions in the higher centres of the brain. In simultaneous synthesis each piece of information is immediately accessible with another and thus information is processed in a wholistic fashion which, in the simplest case, could be via imagery. Successive synthesis involves the processing of information in a time dependent sequential mode where each piece of information has limited connections to others. Positive relationships among information processing style, intellectual giftedness, reading ability and scientific problem solving have been observed. Findings indicate that intellectual giftedness is related to information processing specifically in the area of simultaneous processing (Hafenstein, 1990; Watters, 1993; Watters & English, 1995). Sequential processing appears to be related to reading recognition, while simultaneous processing has a closer relationship to reading comprehension (Hafenstein, 1990).

Integrating both Gardner's and Sternberg's ideas suggests that a child may possess appropriate and necessary cognitive architecture to function exceptionally in one dimension, for example music, but not in others. Such functioning would not be seen by teachers or care-givers as of concern, for being gifted in music can be capitalised on by concentrating on a career in music. Similarly, those gifted in bodily-kinaesthetic, interpersonal, or linguistic dimensions can exploit these talents by engaging in

appropriate tasks. Furthermore, not being gifted in music or sport while showing talents in other dimensions would not perturb parents or teachers. However, in academic dimensions language and mathematics high achievement may depend on an appropriate complement of intelligences or an awareness of how to effectively use the specific intelligences possessed. Certainly mathematics, although identified by Gardner as being associated with "logico-mathematical" intelligence is also dependent on spatial skills (Clements, 1981, 1983; Fennema & Tartre, 1985; Guay & McDaniel, 1977; Krutetskii, 1976). Indeed, Hersberger and Wheatley (1980) lamented the emphasis directed towards analytical thinking at the expense of spatial thinking in the teaching of mathematics. The tasks usually assigned to children in schools are routine and can be solved by the application of a heuristic without the need to engage in higher order thinking. Lampert (1986) in particular has criticised mathematics teaching claiming that the focus is on observable computational procedures rather than developing an understanding of underlying mechanisms.

When engaged in mathematical or scientific tasks both analytical (logico-mathematical) and spatial dimensions of intelligence are potentially being tapped. Given Aaron's exceptional performance in some spatial tasks one would conclude that he possesses the cognitive components involving knowledge generation, performance and metacognitive action in that domain. However, these are not or cannot be applied to tasks frequently employed in classrooms that draw heavily upon the logico-mathematical or linguistic intelligence. In contrast he attempts to use sequential, analytical processes to solve problems. His reluctance to complete many set activities is consistent with an inability to solve these specific tasks in contrast to his strong engagement in tasks that he selects for himself. Thus tasks where he draws on spatial intelligence are completed at an exceptional standard whereas he is less successful in tasks that he attempts to solve using logico-mathematical intelligence. Because he is extremely successful in some areas, feedback may be inconsistent. His achievements are acknowledged, his failures attributed to external events.

Aaron's strong spatial intelligence was shown by his performance on the psychometric tasks undertaken during his interview. He was assessed using Raven's Coloured Progressive Matrices (Raven, Court & Raven, 1986), and with a series of matrix memory and digit/letter span tasks that test simultaneous and successive synthesis as defined by the Luria model. On the Raven's test Aaron was in the 95 percentile range of achievement and in the Luria dimensions was in the 90 percentile on simultaneous synthesis but only in the 5 percentile range in successive synthesis. This extreme imbalance in information processing aptitude is consistent with a high spatial ability but indicates a very low proficiency in processing sequential information. Thus, he lacks the flexibility and capacity to order information and process rules or heuristics. It was noted that while reading problems aloud he frequently misread words and stumbled over simple words although he seemed to comprehend the meaning of the sentence, but not necessarily understand or be able to represent the problem. In contrast, he was very fluent in the interpretation and oral use of complex scientific language.

During a discussion about the phase changes of water several noteworthy observations were made. The interview situation involved an open-ended discussion of the process of evaporation. A container of ice, a container of water and a container of boiling water were placed before him. In the discussion questions about the role of heat in the evaporation process were posed. His responses indicated a large knowledge base with a sophisticated understanding of the process for a child of his age. However, he demonstrated an inability to anticipate and condense the theme and was unable or unwilling to engage in elaboration. The session became almost one of question and answer in which he eagerly participated. Indeed, he was co-operative and keen to talk about what he knew. A disturbing feature was that his responses were reactive rather than reflective or elaborative of the concept under consideration. When discussion centred on real-world scenarios with which he would be familiar, for example problems about what happens to wet washing on the clothes line, answers were based on what he had read or experienced. There was little evidence of the creative thought necessary to generate causal relationships.

Creative thought is an important characteristic of the gifted which results in lateral responses to problems or deviations in which a new problem may be proposed. This implies a greater need for autonomy with the opportunity for children to select meaningful problems which they can solve by constructing links between disparate components of the problem. Having appropriate and flexible cognitive representations of knowledge is an asset that facilitates analogical problem solving skills.

However creative thought should be considered as distinct from creativity due to the differential output of each process. Creative thinking results in new ideas whereas creativity results in insight.

The difficulties of a young gifted child (continued)

Creativity and insight

Four phases of creativity are repeatedly seen in high achieving gifted adults who have successfully solved major problems: *preparation, incubation, illumination and verification*(Boden, 1990). The insight that appears to accompany their achievements corresponds to the illuminatory phase of creativity. The biographies of eminent scientists highlight the lengthy preparation and incubation that often preceded the illumination, hence insight is chronologically and experientially linked to the individual, culminating in an intense moment of illumination or insight. For example, such phases are evident in the life of Kekulé. Confronted with the problem of understanding the structure of benzene, history records that he was presented with the solution while dozing before his fireplace. Images of snakes gambolling before his eyes in the fire provided an illuminating experience in which he conjectured the structure of the benzene molecule. However, this experience was prefaced by a long period of time incubating the problem which was an extension to his successful hypothesis of the bonding characteristics of the carbon atom. Thus the insight evident that night before the fire was contingent on prior expertise, preparation and engagement with the problem.

Obviously, Aaron as a child would not have the extensive experience and knowledge base necessary for domain expertise. However, relative to his peers he is in some fashion exceptional. How did he engage in problem solving? Firstly, there was little evidence in the chemistry task of creative, insightful thinking by Aaron. Perhaps, such a domain requires a considerable experiential base and given the open-ended nature of the interview the problem may have been too abstract for him. How did he perform in a more convergent problem solving situation? He was also presented with a series of novel mathematics problems which he worked through with the researcher. Although presented with some six problems, he was given the opportunity to select three he wanted to do and felt that he could solve.

Mathematical problem solving

In contrast to his normal classroom behaviour which was marked by task avoidance or failure to complete set tasks Aaron appeared to focus on task completion during this interview. His perception of "solving the problem" appeared to be to rapidly produce an answer. However when questioned about what he was asked to find out he was unable to link the computed answer to the problem. Hence his focus in this interview was on the product rather than the process of problem solving. Throughout the interview he was co-operative and enthusiastic but his level of problem engagement seemed low as he only proceeded further with the problem when questioned or queried by the researcher.

Despite having highly developed spatial and drawing skills Aaron did not use diagrams spontaneously during the solution process. This may be because diagrams can be thought of as "cheating" in a conventional mathematics classroom (Shigematsu & Sowder, 1994). When requested to use a drawing in the following task in fact Aaron experienced spatially related difficulties.

> There are 4 separate large boxes, and inside each large box there are three separate medium-sized boxes, and inside each of these medium-sized boxes are two smaller boxes. How many boxes counting all sizes are there together?

Firstly, Aaron assigned to the size cues of *large, medium and small*a proportional relationship of 1:4:8 as illustrated in Figure 1 thereby introducing extraneous information which subsequently misled him.

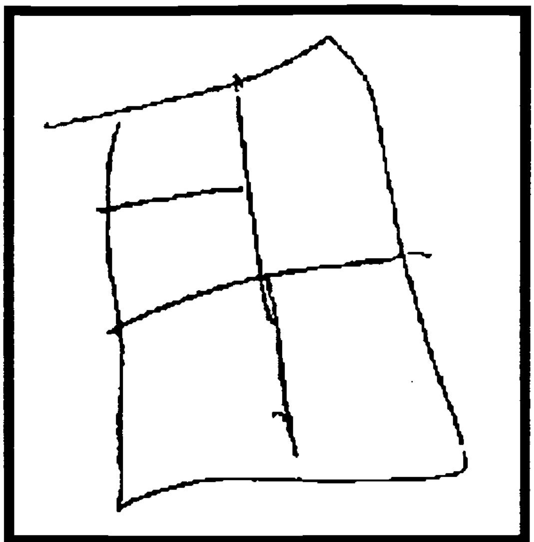

Figure 1. Proportional relationships

Secondly, Aaron ignored the location cue of inside in drawing the previous diagram and when asked specifically to draw small boxes inside a medium box drew two smaller boxes but in the incorrect location. After he was questioned about the location of the boxes he redrew the diagram with the boxes correctly positioned as shown in Figure 2..

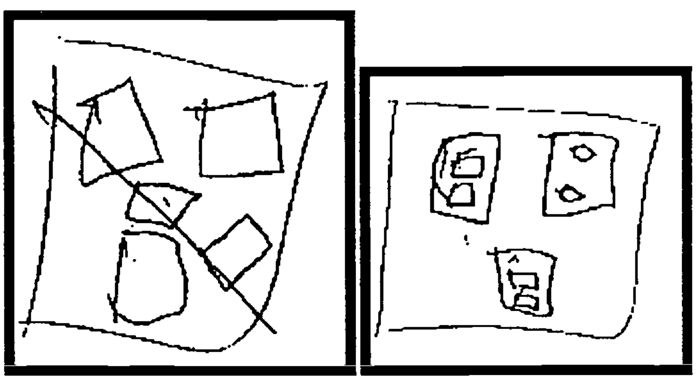

Figure 2. Inside the small boxes

Thirdly, in addition to the difficulties Aaron had in generating an appropriate diagram he failed to recognise that the number of boxes in each large box was identical despite the visual evidence. He counted each box individually, initially incorrectly, and then correctly after a query by the researcher.

Aaron's performance on this task presents an anomaly as the evidence suggests that Aaron is spatially gifted yet he could neither generate nor use a diagram in problem solving and he ignored or was confused by the spatial language. In fact his problem solving appeared to be numerically-oriented considering his use of spatial cues and procedures. However lack of experience or instruction in the use of the diagram as a visual tool are plausible reasons for Aaron's poor performance on this task.

In a second task which involved putting 5 playing cards in the correct order based on a series of clues

Aaron also exhibited difficulty with spatial language related to position. He confused *left*and *right*and misinterpreted *immediately to the left/right of*and *between.*

The third task was a division word problem involving the distribution of loaves of bread among a number of families, its novelty due to the need to divide 48 by 9 without a remainder, a task which Aaron would not have been introduced to yet at school. Aaron successfully completed the operation using a long division algorithm and revealed that his mother had taught him this procedure. Immediately upon completing the computation he was asked the question in the problem: "How many (loaves) will each family receive if they are given the same amount?" There was a lengthy pause and although the computation was instigated after reading the problem Aaron was unable to connect the answer he had produced to the problem.

His lack of connection between mathematical ideas was also evident in his drawing of the answer 5.3. He explained that the was a recurring decimal but in drawing the decimal component of the answer he drew a third of a loaf of bread for each "3". He took the notion of each 3 as a third a step further and stated that .333 was three thirds and therefore one. His identical representations for .3, .03 and .003 are show in Figure 3 and suggests that he does not understand place value.

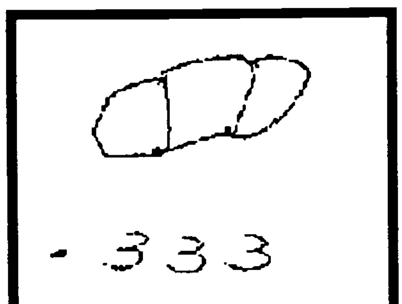

Figure 3. Depiction of a recurring decimal

Although Aaron seems to be mathematically advanced for his age his advanced ideas relate to discrete mathematical information such as the long division procedure and recurring decimals rather than mathematical knowledge which requires the learner to make connections among the mathematical ideas. Throughout these tasks his focus was on the computation of numbers rather than making connections among mathematical ideas as a sense making process. He was unable to develop a cogent problem representation, work systematically and reflect on his progress during problem solving. Aaron's problem solving was therefore adversely affected by his lack of enabling skills (Resnick, 1987).

Summary of Aaron's cognitive and affective characteristics

The evidence that we have suggests that Aaron has particular strengths in what Gardner would describe as spatial intelligence. On tasks that demand facility in this dimension he can display a very high order of creativity. He also possesses a large knowledge base built on personal experiences and extensive reading.

In contrast his performance on classroom tasks that involved the use of logico-mathematical reasoning was erratic. His difficulty in mathematics seems to stem partially from an inability to choose an appropriate mode of operation to solve problems. His prior experience has encouraged him to adopt sequential heuristics, e.g. long division, in attempting to solve a problem whereas his strengths in visualisation were not employed in order to construct an appropriate representation of the problem. His problem is compounded by lack of feedback that impacts on his metacognition. The feedback does not challenge his choice of strategy nor encourage him to become reflective. He approaches tasks with speed

as an objective rather than accuracy although, if not initially successful, he will expend enormous effort and energy but to no avail. However, he makes little attempt to analyse his errors.

The effectiveness of his knowledge acquisition processes is a concern as he displays difficulty in disembedding relevant information, building relationships between information and making appropriate links with stored information in some situations. Thus although he has a large memory capacity he does not operate on it efficiently in all situations.

Observations of Aaron in the classroom, feedback from his parents and his behaviour within the enrichment programme all contribute to the perception that Aaron has a strong self-concept and is confident in his abilities. In the classroom his eccentricity is well tolerated by the teacher and his peers. Indeed he is perceived to be a popular child. Of interest is that he does not seem to reciprocate feelings. He tends to be oblivious to much of the social interaction that surrounds him and is insensitive to any negative social feedback.

The key solution to Aaron's situation is that he needs support not to work "harder" but to work "smarter." Successful problem solving requires both knowledge of problem solving strategies and the metacognitive application of these strategies due to the need to select, implement and evaluate strategies (Narode, 1987). The effectiveness of metacognition appears unrelated to the quantity of metacognition during problem solving because expert problem solvers do not necessarily demonstrate more metacognitive activity than novice solvers (Hart & Schultz, 1985; Simon & Simon, 1978) but are metacognitively oriented in that they are metacognitive at certain points in the solution process when redirection occurs in a solution path (Lesh, 1983). Conversely failure in problem solving can be linked to the absence with metacognitive activity (Lesh, 1983).

In fact metacognition may be difficult to detect in experts due to the automaticity of their problem solving (Hart & Schultz, 1985; Silver, Branca & Adams, 1980) in which cognition and metacognition are integrated. Metacognition may not be needed to complete a routine problem if the task is not sufficiently challenging (Silver, Branca & Adams, 1980). Simple, routine tasks presented in class provide no opportunity for gifted children to engage in metacognition. The solution of routine mathematical problems is modelled on a strategy of selecting the right algorithm and proceeding sequentially and mechanically to the solution. The problems are insufficiently challenging to afford opportunities for teachers to model metacognitive strategies. Additionally, in a transmissive approach an emphasis is on information without the opportunity for students to construct both conceptual and procedural knowledge. Thus an essential contribution teachers need to make is to provide support in the development of metacognition:

> *... the most important pedagogical contribution for the development of metacognitive skills is the instilling of an awareness that one needs to take conscious, planful action when learning mathematics and science, and in problem solving*(Narode, 1987, p. 13)

An important characteristic of experts in a particular domain is that they know to adopt strategies in which they are competent (Anderson, 1985).

Aaron needs to know how to capitalise on his strengths and to circumvent his weaknesses. He needs opportunities to develop metacognitive skills in order to identify the knowledge he has and the strategies for using that knowledge. Such metacognitive development is dependent on an appropriate environment in which challenging, novel problems can be explored.

Strategies for intervention

The case of Aaron is by no means unique. In our studies we have seen a number of children with similar characteristics. Aaron and those like him present special challenges to teachers. Not only is there the challenge of identification but there is also the challenge of developing the appropriate strategies to help him.

The availability of strategies for the identification, characterisation and support of gifted children are

widespread and reflect the theoretical stance adopted by the strategist. Of practical significance is that many programmes for the gifted are developed on theoretical models and influenced by theorists who rely on practitioners for identification. Thus, while theorists may debate the role of creativity, task commitment and ability (Renzulli, 1977), or distinguish between the *successful*, the *challenged*, the *underground*, the *gifted*, and the autonomous etc. child (Betts, 1985), or seek qualitative indicators of exceptional learning abilities and specific aptitudes, practitioners are confronted with the reality of an exceptional child in a classroom of children all with unique personalities and characteristics. The criteria applied by teachers indeed has been shown to be dependent on their experiences with gifted children with the more experienced teachers adopting criteria consistent with those of the theorists (Schack & Starko, 1990). However, a significant role for teachers is that of talent scout where teachers seek more qualitative understandings of individual children's abilities and provide support accordingly. Children like Aaron have the potential to make an enormous contribution to society.

Our continuing experiences with Aaron and his involvement in our enrichment programme has provided us with an opportunity to explore ways of helping him and children like him realise their potential. Our enrichment programme developed out of a need recognised by many parents, teachers and schools for a programme that catered for very young gifted children. The operation of the programme has been rationalised and justified by drawing on the research conducted with gifted and normal children. Our evolving model is described below.

The difficulties of a young gifted child (continued)

An Intervention model

Bereiter and Scardamalia (1992) describe three types of teachers who adopt different approaches to teaching: Type A teachers, Type B teachers and Type C teachers. Type A teachers emphasise students doing work selected and justified by the teacher. Type B teachers assume responsibility for planning, establishing prior knowledge, generating thought-provoking questions and evaluating understanding. Type C teachers focus on developing in students the ability to develop metacognitive processes and autonomy. It is this third approach that has the greatest potential for impacting on gifted children like Aaron. The important focus in an intervention that leads to autonomy is to ensure that the student is active in the process whereby he/she comes to understand the role they play in the classroom. In developing autonomy the perceived responsibility for the child's learning moves from the teacher to the child. Thus, the central task of teaching is to enable the student to perform the tasks of learning (Fenstermacher, 1986).

In Type C teaching there is an explicit obligation to develop metacognitive skills. The focus should be on helping children assume responsibility for their own learning by facilitating the development of a perceptive understanding of their own cognitive characteristics and strengths. This does not occur spontaneously in children and therefore, for the realisation of their talents, one needs to intervene to enable the development of metacognition. The teacher's task includes instructing the learner on the procedures and demands of the role, selecting the material to be learned, adapting that material and constructing the most appropriate set of opportunities for the student to gain access to content, motivation and to monitor and appraise their own progress.

Thus in supporting children with specific needs, such as Aaron, a process of individualised instruction needs consideration. The model that we describe is applicable to all gifted children dependent on initial identification and consists of six strands of activities. Once engaged in the process individual differences can be accommodated. Our model is influenced by the strategies of Renzulli's (1977) Enrichment Triad Method which has been extensively adopted and implemented with success (Renzulli & Reis, 1994) and the Autonomous Learner Model of Betts (1985). The key strands that we envisage as necessary in our context are: *expanding experiences, establishing a social environment, cognitive apprenticeship, development of affect, co-operative groups and knowledge creation*. The ideal initiative is the withdrawal of Aaron from the classroom for a period on a regular basis during which time he is given the opportunity to work with other gifted children. The six strands described are sequential in so far as it is necessary to develop a rapport with individual children and to respond to their needs. Hence, activities within each strand overlap and are integrated depending on reactions and feedback from the child. The teacher's awareness of each child's developing interests and needs will influence the extent to which each strand is implemented.

Provision of new experiences. The first strand of intervention focuses on identification of learning styles and provision of a range of activities to expand the children's spectrum of interests. Qualitative information provided by the parents is one way to identify learning styles. Further information is obtained by implementing a variety of tasks which are based on the information processing theories of Luria and which provide information about their information processing attributes in terms of simultaneous and successive synthesis. We specifically seek information about interests in order to expand those interests by providing a range of activities in science, mathematics and problem solving in formats that match the child's preferred learning style (Sternberg, 1994a).

Socio-emotional environment. An essential component of the model is the ability to establish a learning environment that encourages flexibility, laterality and reflectivity. The interaction between the internal world of the child and his/her external world is the cornerstone of achievement (Sternberg, 1990). Clark (1988) highlights the importance of optimal development in early childhood and the establishment of an effective environment. Home variables and family interactions are crucial elements in the pre-school stage later extended by effective teachers and formal learning environments (Renshaw & Gardner, 1990). The development of metacognitive skills is also conditional on the social interaction and

environment experienced in the home and school (Kurtz, 1990; Moss, 1990).

Establishment of a social environment in which like-minded or intellectually gifted children associate with each other as peers is essential. Gross (1989) argues that the gifted are as exceptional in emotional and social development as they are in intellectual precocity. Gifted children display a high sense of social justice and engage in more abstract discussions than their age peers. Hence, serious communication problems and social ostracism can arise when gifted children attempt to share interests with age peers. Thus the gifted child subjected to peer pressure to conform to the prevalent social norms may lose their motivation to succeed in intellectual pursuits. When interacting with their peers we find that children reassess their own self-concept. For example, one child reflected on how difficult it was for him to talk with other children at school and how their reactions to his interests were negative. After interacting with his intellectual peers in the enrichment programme he stated that he finally "felt OK" about himself.

Cognitive apprenticeship. The development of problem solving skills (knowledge acquisition, processing and metacognitive functions) through modelling, coaching and mediated learning experiences is described in Table 1. These approaches are dependent on teachers helping students assimilate new experiences into existing schemata, scaffolding and modelling (Feuerstein, 1980; Vygotsky, 1978). Particularly important are adults who demonstrate a learning orientation rather than a performance goal and a focus on problem solving and metacognitive strategies rather than knowledge accumulation (Moss & Strayer, 1990; Renshaw & Gardner, 1990). Cognitive apprenticeship implies responsibilities for both students and teachers. The teachers through modelling, coaching and scaffolding provide the impetus for children to engage in articulation, reflection and exploration. Clearly, it is important that the child does respond accordingly if the process is to be successful.

Table 1
Six teaching methods characteristic of cognitive apprenticeship
(adopted from Collins, Brown and Newman, 1989)

Method	**Modelling**
Focus	teacher demonstrates the thought processes of expert performance
Coaching	teacher focuses on helping with problems while students are in the process of problem solving
Scaffolding	teacher provides external problem solving support which is slowly withdrawn as students become more competent
Articulation	students verbalise or demonstrate their own knowledge and processes in a domain
Reflection	students compare problem solving processes with peers or adult model
Exploration	students independently seek out new problems

*Affective development.*Concomitant with cognitive development is the development of affect. The emotional status of gifted children is a prime concern. A focus on knowing and understanding self is an important objective of the intervention programme (Sternberg 1994b). Bandura (1986) argues strongly that educational practices should be gauged not only by the academic parameters but also by the impact they have on children's beliefs about themselvesself-efficacy. Developing self-efficacy is a long term process. Young children are relatively unstable in their beliefs reacting to immediate experiences without integrating multiple social and cognitive experiences. They discern their own capabilities through social comparison of their successes and failures contrasted with their peers. By observing effective models, and vicarious experiences supported by realistic feedback they develop a sense of self-efficacy. An important process in our intervention is for tutors to identify efficacy-relevant cues and to provide constructive feedback from experiences on various tasks. It is important that children

understand the reasons for success and failure.

Co-operative groupings. Working together in small co-operative groups helps children to develop self-esteem, intragroup relationships and recognition of each other's strengths and weaknesses. Membership is usually self-selecting but frequently groups are deliberately constructed by the tutors to capitalise on or respond to individual differences in styles, interests and capabilities. The research evidence supports the use of co-operative groups that are constructed with the goal of group achievement (Slavin, 1991) at least in normal classes. In our experience group work facilitates the production of knowledge through sharing, brainstorming, group synergism and allows individuals to assume responsibilities and fulfil obligations to the group.

Creation of knowledge. Gifted children have little difficulty in mastering content knowledge, the challenge they seek is to integrate that knowledge by applying it to real problems. This is initiated in our model by introducing small projects in which children report on discrete undertakings. The structure in one sense has a focus on play, fantasy and hypothetical situations but also introduces some of the rigour of scientific methodology. Thus in this context independence and autonomous involvement in knowledge generation develops. Involvement becomes external to the group, public, and affords risk-taking opportunities. Ownership of a problem stimulates their commitment to solving the problem and with help many of the children become engaged in long-term investigations often to the economic detriment of parents who finance the endeavours. We encourage children to engage in external competitions as a mechanism to achieve independent research for intrinsic satisfaction.

A summary of our objectives indicated by this model is given in Table 2. We acknowledge that children enter our programme at various levels of achievement. In terms of their interests for example some have very narrow fixations such as an intense fascination with dinosaurs or astronomy without having ever explored or even been aware of other domains of science. Once again, family background may strongly influence opportunities to engage in broader interests. At the end of the intervention we find children more willing to engage in new endeavours and a willingness to share their interests with others. The programme through all the strands attempts to support a transition from a situation where the child is often alone, isolated and whose needs may not be recognised to a situation that supports their optimal performance.

Implementation of this model is dependent on a high teacher-student ratio and particularly skilled and experienced teachers who are confident in becoming facilitators of learning rather than directors. In the programme we operate with a facilitator who works with two student teachers as a team mentoring some 15-18 children. Some of the key attributes of effective mentors include patience, high energy, flexibility, empathy, a sense of self-confidence in their ability to build rapport with children and provide modelling of effective problem solving strategies. An extensive knowledge base in mathematics and science is not necessary but a knowledge of the processes of science is advantageous. A capacity to work in a team and display initiative in reacting to situations is imperative. These attributes are not always found to be well developed in pre-service teachers but working under the guidance of an effective facilitator many skills are developed in those who display a willingness to learn. Many of the important attributes of effective mentors are similar to those described by Baldwin (1993). Formation of an effective enrichment group assumes a critical mass of participants, a situation that may not always be possible in isolated or small schools.

Table 2.
Desirable goals in the model of intervention

Strand	Entry State	Goal State
Expanding experiences	Experiences broad and imposed	Experiences self selected
Social environment	Novel - supportive and contrived - teacher directed - establishing codes of behaviour	Secure, autonomous, constructivist
Cognitive apprenticeship	Identifying learning styles, gifts and skills	Repertoire of problem solving components and strategies for knowledge acquisition
Affective development	Egocentric, withdrawn, feelings of isolation, superiority, hyperactivity	Knowledge of self and others
Co-operative groupings	Adult orientation	Self selected, team work, acceptance and valuing peer support
Creation of knowledge	Assimilation of information	Generation and application of knowledge

Conclusions

Our objectives are to ensure that children such as Aaron achieve their potential. Sternberg's (1993) pentagonal theory provides a benchmark that informs us of the extent to which they are indeed achieving their talent. His pentagonal theory emphasises intelligence as being translated into real world performance and success. He asserts that five criteria are implicated in the assignment of giftedness. The excellence criterion recognises that an individual will be judged as highly skilled relative to peers in some area. A rarity criterion supplements the excellence criterion because it is necessary for the gifted person to possess an attribute which is rare relative to his or her peers. It is not sufficient for the person to be achieving highly in an area of unique interest to themselves that is not appreciated socially. Emphasis is placed on product and people whose potential is not realised are not labelled as gifted. The individual also needs to be able to demonstrate in one way or another that he or she is gifted by success on tests that are valid assessments. Finally, these four criteria are reinforced by a value criterion through which one attempts to identify how valued or significant is the individual's area of excellence.

Those whose contributions are valued are recognised as gifted. If their behaviours are idiosyncratic and not valued in a conventional school setting there exists doubt about their giftedness. Failure to foster an environment that provides opportunities may then contribute to a lack of realisation of children's potential. There are many examples of unusually gifted people who were "underachievers" as children but were ultimately able to achieve as adults. Anecdotes from the last four centuries record outstanding cases of gifted people among scientists and mathematicians, especially the spatially gifted, whose experiences are enigmatic (MacFarlane Smith, 1964). In many cases their spatial intelligence was evident in the interests and abilities during their early childhood. Among the famous, Pascal, Monge and Einstein were noted for their geometric ability, whereas Watt and Newton were acknowledged for their high levels of practical skill. Newton was mechanically adept. Monge and Baird had particular ability in engineering and Baird was a tinkerer. Pascal was recognised as a prodigy in geometry. In contrast, however, Einstein was not considered to be a high achiever despite having taught himself Euclidean geometry at 12 years of age. In their teens Pascal and Monge demonstrated extraordinary spatial ability. At 12, Pascal discovered for himself the properties of geometrical figures and that the sum of angles of a triangle is equal to two right angles. Later at 16 he wrote an essay on conic sections and at 18

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constructed an adding machine.

The academic performance of many of these eminent scientists was frequently very poor, considering their later outstanding achievements. Newton, Einstein, Trevithick and Watt were all underachievers at school. Newton reported that he did badly at school, Einstein was an unsatisfactory pupil, Trevithick was slow, and Watt was described as a backward scholar, "dull and inept." When Einstein revisited his old high school, even the teacher who inspired him most could not remember him. The performances of these people within the school environment did not match that valued by the system operating that is a facility with logico-mathematical and linguistic ability.

Although the spatially gifted seem to have acute visual powers, they expressed difficulty in communicating with non-visualisers. Several of the spatially-oriented field seemed ill at ease with language. Einstein considered that "words or the language, as they are written or spoken did not seem to play any role in his mechanism of thought" which was visual or muscular. The words were sought laboriously when the associative play could be reproduced at will. Einstein was so slow to begin speaking that his parents were afraid that he was abnormal. Even at school as a 9 year-old his speech still lacked fluency and everything he said was expressed after consideration and reflection (MacFarlane Smith, 1964). Additionally, many spatially-oriented individuals were also ill at ease with written communication. Accordingly speech and writing may be a second language for some spatially-oriented people because graphicacy is their primary language. In a similar manner, Aaron appears to be a child who is spatially gifted at the expense of language and logico-mathematical ability.

In all, the characteristics of the spatially gifted put them at odds with their more traditional high achieving peers. Insufficient is known about what triggered the transition from under achievement in youth to excellence in adulthood. However, given that such transition occurred with these people does not guarantee that it will spontaneously occur with all spatially gifted children especially those whose intelligence is constrained to one dimension. We do know that the positive impact of a significant adult or a stimulating critical incident was important in the lives of many eminent persons. A number of studies have implicated early identification, significant adult influences and a supportive or challenging socio-cultural environment as major factors in the development of intelligence and the realisation of potential (Devlin & Williams, 1992; Feldman, 1986; Karnes & Johnson, 1991). Indeed the mediatory role of the socio-emotional, cultural and learning environments are key considerations. Hence intervention with children such as Aaron who displays some of the key characteristics identified in these historically eminent thinkers is imperative. Open-mindedness and dedication to the individuality of children's gifts and a belief in their potential are seminal ingredients in providing enrichment for the Aarons of the world.

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